U.S. Department
of Transportation

**Federal Aviation
Administration**

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U. S. Department of Transportation

Federal Aviation Administration

Specification

ELECTRICAL WORK, INTERIOR

CONTENTS

1. SCOPE

1.1 Scope.- This specification covers the minimum requirements for interior electrical work at FAA facilities. Where the phrase "unless otherwise indicated" or similar wording appears, it refers exclusively to other documents that are specific parts of the contract.

2. APPLICABLE DOCUMENTS.- The current issues of the following documents in effect on the date of the invitation-for-bids or request-for-proposals form a part of this specification, and are applicable to the extent specified herein.

2.1 Federal specifications

CC-M-1807	Motors, Alternating Current, Fractional and Integral Horsepower (500 H.P. and smaller)
J-C-30	Cable and Wire, Electrical (Power, Fixed Installation)
W-B-30	Ballast, Fluorescent Lamp
W-C-375	Circuit Breakers, Molded Case; Branch Circuit and Service
W-C-582	Conduit, Raceway, Metal, and Fittings; Surface
W-C-586	Conduit Outlet Boxes, Bodies, and Entrance Caps, Electrical: Cast Metal - For Shore Use
W-C-1094	Conduit and Conduit Fittings; Plastic, Rigid
W-F-414	Fixture, Lighting (Fluorescent, Alternating Current, Pedant Mounting)
W-F-1662	Fixture, Lighting (Fluorescent, Alternating Current, Recessed and Surface Ceiling)
W-J-800	Junction Box; Extension, Junction Box: Cover, Junction Box (Steel, Cadmium or Zinc - Coated)
W-L-305	Light Set, General Illumination (Emergency or Auxiliary)
W-P-115	Panel, Power Distribution
W-S-610	Splice, Connector
W-S-865	Switch, Box (Enclosed), Surface - Mounted
WW-C-540	Conduit, Metal, Rigid: and Coupling, Elbow, and Nipple, Electrical Conduit: Aluminum

WW-C-563	Conduit, Metal, Rigid: Electrical, Thin-Wall Steel Type (Electrical Metallic Tubing); Straight Lengths, Elbows, and Bends
WW-C-566	Conduit, Metal, Flexible
WW-C-581	Conduit, Metal, Rigid; and Coupling, Elbow, and Nipple, Electrical Conduit: Zinc Coated
QQ-W-343	Wire, Electrical, (uninsulated)

(To obtain copies of federal specifications, contact General Services Administration offices in Washington DC, Atlanta, Boston, Chicago, Dallas, Denver, Kansas City MO, Los Angeles, New York, San Francisco, or Seattle.)

2.2 Military specifications

MIL-P-15147	Primer and Enamel, Coal Tar
MIL-R-21931	Resin, Epoxy

(Single copies of military specifications, standards, and handbooks may be requested by mail or telephone from Naval Forms and Publications Center, 5801 Tabor Ave., Philadelphia, PA 19120. Not more than five items may be ordered on a single request; the invitation-for-bids or contract number should be cited where applicable. Only latest revisions (complete with latest amendments) are available; slash sheets must be individually requested. Request all items by document number. For information on subscription service, direct inquiries to the above address with additional marking, "ATTN: CODE 56."

2.3 Federal Aviation Administration specification

FAA-E-1391	Installation and Splicing of Underground Cables

(Copies of FAA specifications may be obtained from the Contracting Officer in the office issuing the invitation-for-bids or request-for-proposals. Requests should fully identify material desired, i.e., specifications, standard, amendment, and drawing numbers and dates. Requests should cite the invitation-for-bids, request-for-proposals, or the contract involved or other use to be made of the requested material.)

2.4 National Fire Protection Association (NFPA) publications

No. 70	National Electrical Code (NEC)
No. 78	Lightning Protection Code

(Requests for copies of NFPA publications should be addressed to the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.)

2.5 National Electrical Manufacturers Association (NEMA) standards

OS 1	Sheet Steel Outlet Boxes, Device Boxes, covers and Box Supports
ST 20	Dry Type Transformers for General Applications
VE 1	Cable Tray Systems
WC 5	Thermoplastic Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
WD 1	General Requirements for Wiring Devices

(For copies of NEMA standards, contact the National Electrical Manufacturers Association, 155 East 44th St., New York, NY 10017.)

2.6 Underwriters' Laboratories, Inc. (UL) standards

UL 50	Cabinets and Boxes
UL 96A	Installation Requirements for Lightning Protection Systems
UL 542	Lampholders, Starters, and Starter Holders for Fluorescent Lamps
UL 870	Wireways, Auxiliary Gutters and Associated Fittings
UL 1242	Intermediate Metal Conduit

(For copies of UL standards, contact Underwriters' Laboratories Inc., Publication Department, 333 Pfingsten Rd., Northbrook, IL 60062.)

2.7 Institute of Electrical and Electronics Engineers (IEEE), Inc. Standards

STD C57.12.80	IEEE Standard Terminology for Power and Distribution Transformers
STD 141	IEEE Recommended Practice for Electric Power Distribution for Industrial Plants

(For copies of this standard, contact the IEEE Inc., Standards Department, 445 Hoes Lane, PO Box 1331, Piscataway, NJ 08855-1331.)

2.8 Other documents

2.8.1 Local utility companies.- The rules and regulations of the local utility companies providing service.

2.8.2 Local governing bodies.- The rules, regulations, and codes of local governing bodies.

3. MATERIALS

3.1 General.- The contractor shall furnish all materials not specifically identified as Government Furnished Materials in the invitation-for-bids or contract. Materials and equipment shall comply with all requirements of the contract documents. Materials furnished by the contractor shall be new, the standard products of manufacturers regularly engaged in the production of such materials, and of the manufacturer's latest designs that comply with the specification requirements. If materials and equipment requirements conflict, the order of precedence for selection shall be as follows: special contract provision, the contract drawings, this specification, and then in continuing order of precedence, referenced FAA specifications, Military specifications, Federal Specifications, NFPA publications, IEEE standards, UL standards and NEMA standards. Wherever standards have been established by Underwriters' Laboratories, Inc., the material shall bear the UL label.

4. INSTALLATION

4.1 General.- The rules, regulations and reference specifications enumerated herein shall be considered as minimum requirements. FAA requirements often exceed those of other standards organizations such as the NEC. Adherence to other standards shall not relieve the contractor from furnishing and installing higher grades of materials and workmanship when so required by this specification. Adherence to this specification shall not relieve the contractor from furnishing and installing higher grades of materials and workmanship when so required by the contract drawings or special contract provisions. This specification shall govern when conflicts occur between it and the documents referenced in para. 2, Applicable Documents, and in the order of precedence established in para. 3, Materials.

4.2 Workmanship.- All materials and equipments shall be installed in accordance with the contract drawings. When manufacturers recommended installation methods conflict with contract requirements, differences shall be resolved by the Contracting Officer. The installation shall be accomplished by skilled workers regularly engaged in this type of work. Where required by local regulations, the workers shall be properly licensed.

4.3 Contract drawings.- Where the electrical drawings indicate (by diagram or otherwise) the work intended and the functions to be performed, even though some details are not shown, the contractor shall furnish all equipment, material (other than the Government-furnished items, see para. 3.1) and labor to complete the installation work and to accomplish all the indicated functions of the electrical installation. Further, the contractor shall be responsible for taking the necessary actions to ensure that all electrical work is coordinated and compatible with architectural, mechanical, and structural plans, and the layout of any special electronic equipment.

4.3.1 Minor departures.- Minor departures from exact dimensions shown in electrical plans may be permitted when required to avoid conflict or unnecessary difficulty in placement of a dimensioned item, provided all contract requirements are met. The contractor shall promptly obtain approval

from the Contracting Officer prior to undertaking any such departure and shall provide appropriate documentation of the departure.

4.4 Grounding

4.4.1 General.- FAA grounding requirements often exceed those of the National Electrical Code (NEC). Therefore, grounding systems shall be as indicated on the contract drawings and as specified herein. In no case, however, shall the NEC be violated.

4.4.2 Grounding electrode conductor.- The grounding electrode conductor shall be bare or insulated (not green) copper and shall be sized as shown in the contract documents. When not indicated in the contract documents, the conductor shall be copper and sized in accordance with Table 250-94 of the NEC (1990 edition), entitled "Grounding Electrode Conductor for AC Systems" except that the conductor shall not be smaller than No. 6 AWG. This conductor shall be connected to the neutral bus in the service disconnecting means and shall extend directly to a ground rod in the grounding electrode system in one continuous unspliced run. Where the grounding electrode conductor is routed through a metal raceway, the raceway shall be electrically continuous and bonded to the conductor at each end. The conductor shall be protected from physical damage in accordance with the NEC.

4.4.3 Grounding electrode system.- The grounding electrode system shall be installed as shown in the co tract documents. Unless otherwise indicated in these documents, the groundir electrode system shall consist of a minimum of four (4) ground rods located . the corners of a structure. Rods shall be spaced apart a distance equal or greater than the length of the rods. Ground rods shall be 3/4 inch b 10 feet, copper or copper-clad steel. Sectionalized type or exothermic butt welded rods shall be used when deeper earth penetration is required. Rods shall be interconnected by a bare copper counterpoise cable forming a closed loop around a structure. The counterpoise cable shall be a minimum No. 4/0 AWG and shall be buried at least 2 feet below grade. The top of the vertically-driven ground rods shall be a minimum of 12 inches below grade. All underground metal pipes and tanks, and the telephone ground, if present, shall be connected to the earth electrode system by a copper cable no smaller than No. 2 AWG. All underground connections shall be made by exothermic welding process unless otherwise indicated.

4.4.4 Grounding electrode system resistance.- The resistance of the grounding electrode system shall not exceed 10 ohms, as tested per para. 5.3.6, unless otherwise indicated. If the measured resistance exceeds 10 ohms, the Contracting Officer shall be notified immediately for further guidance.

4.4.5 Equipment grounding conductor

4.4.5.1 Size.- All metallic non-current carrying parts of electrical equipment shall be grounded with equipment grounding conductors whether or not shown on the drawings. Equipment grounding conductors shall be green insulated copper conductors unless otherwise indicated. When these conductors are not sized, or shown on the contract drawings, they shall be sized in accordance with Table 250-95 of the NEC (1990 edition), entitled "Minimum Size

Equipment Grounding Conductors for Grounding Raceway and Equipment." In no case, however, shall these conductors be smaller than No. 12 AWG.

4.4.5.2 Connections.- Equipment grounding conductors shall be connected to the grounded conductor (neutral) only at the service disconnecting means and at separately derived systems. This connection is sometimes called the main bonding jumper. The equipment grounding conductor shall be installed in the same conduit as its related branch and feeder conductors and shall be connected to the ground bus in the branch or distribution panelboard.

4.4.5.3 Installation.- Where parallel feeders are installed in more than one raceway, a full sized equipment grounding conductor shall be installed in each raceway. Metal conduit housing the equipment grounding conductor shall be electrically continuous, forming a parallel path to the equipment grounding conductor. Under no circumstances shall the equipment grounding conductor be omitted from the electrical system, nor shall any separate grounding system such as the electronic signal ground or direct connections to the earth grounding system, be used for an alternate grounding system or an alternate path to the grounding electrode. All connections to equipment to be grounded shall be made with a grounding connector specifically intended for that purpose. Bare wire, wrapped around connecting screws or mounting bolts and screws, is not acceptable as a grounding connection. All ground lugs shall be of a noncorrosive material suitable for use as a grounding connection, and must be compatible with the type of metal being grounded. Ground lugs shall be mounted on clean, bare metal surfaces that are free of paint, rust, etc.

4.4.6 Raceway grounding.- Surface metal raceways, wireways, or cable rack systems shall be installed in a manner that assures electrical continuity, or short bare copper bonding jumpers shall be installed between adjacent raceway sections to assure proper bonding. Unless otherwise indicated, the minimum size for these bonding jumpers shall be No. 6 AWG. Where aluminum raceways are used, the jumpers shall be bonded with approved connectors for the dissimilar metals.

4.4.7 Other grounding systems.- Any additional grounding systems used for electronic equipment shall be connected directly to the exterior earth electrode system. Other grounding systems shall not be used in place of the equipment grounding conductor system. The conductor used for other grounding systems shall be color coded: green with a bright yellow stripe for single point (isolated) signal ground, green with a bright orange stripe for multipoint signal ground, or green with a bright red stripe for high energy transient ground.

4.5 Lightning protection

4.5.1 General.- Lightning protection systems, where shown on the contract drawings, shall be in accordance with the applicable parts of NFPA No. 78 and shall be installed to meet the installation requirements of UL 96A. All materials used shall be UL approved for use in lightning protection systems. Signal and power conductors shall be separated from lightning protection conductors to the maximum extent possible. If signal or power conductors must be installed within 6 feet of lightning protection conductors, as measured by

the most direct path, i.e., through walls, these conductors shall be installed in heavywall rigid steel conduits. Shop drawings, prepared by the contractor for the installation of the system shall show the manufacturer's catalog number and the exact location of each item of the lightning protection system. These drawings shall be submitted to the Contracting Officer for approval in accordance with para. 5.2.

4.5.2 Connections below grade.- All underground connections from lightning protection system down conductors shall terminate at ground rods in the grounding electrode system with exothermic welds.

4.5.3 Transient protection.- The high energy transient ground bus for transient protection devices shall be connected directly to the grounding electrode system using the most direct path, without loops, sharp bends or kinks.

4.5.4 AC surge arresters.- The AC surge arrester shall be installed adjacent to (within 12 inches) and connected to the line side of the service disconnecting means. This arrester shall be compatible with the service voltage, and shall be wired to avoid loops, sharp bends and kinks, and to minimize the number of bends. There shall be no interconnection between neutral and ground within the arrester. Arrester conductors shall be No. 4 AWG insulated copper or larger, unless a smaller size is recommended by the arrester manufacturer.

4.6 Wiring methods

4.6.1 General.- Unless otherwise indicated, wiring shall consist of insulated copper conductors installed in conduit. In single-phase systems (120 volt, two wire and 120/240 volt, 3 wire), one grounded conductor (neutral) shall accompany each ungrounded phase conductor (120 volt systems) or ungrounded phase conductor pair (120/240 volt systems) powered from a circuit interrupting device. In three-phase, wye, 4-wire systems, one grounded conductor (neutral) shall accompany the three related ungrounded conductors fed from a circuit interrupting device. All neutral conductors shall extend from the neutral bus in the device where the active conductors originate. Device terminals for connection of more than one conductor shall be specifically designed for that purpose.

4.6.2 Raceway system.- Minimum conduit or tubing size shall be 3/4-inch unless otherwise specified. Each run shall be complete, and shall be fished and swabbed before conductors are installed. Ends of conduit systems not terminated in boxes or cabinets shall be capped. Exposed raceways shall be installed parallel to or at right angles with the lines of the structure. Crushed or deformed raceways shall not be installed. A pull wire shall be installed in all empty tubing and conduit systems in which wiring is to be installed by others. The pull wire shall be No. 14 AWG zinc-coated steel, or plastic with a minimum 200-pound tensile strength. Ten inches of slack shall be left at each end of the pull wire. Sections of raceways which pass through to damp, concealed, or underground locations shall be of a type allowed for such locations by the NEC, and shall extend a minimum of 12 inches beyond the damp, concealed, or underground area. Where conduit has to be cut in the field, it shall be cut square using a hand or power hacksaw or approved pipe cutter using cutting knives. The cut ends of the field-cut conduit shall be

reamed to remove burrs and sharp edges. Where threads have to be cut on conduit, the threads shall have the same effective length and shall have the same thread dimensions and taper as specified for factory-cut threads on conduit. Where conduits penetrate walls or floors separating the building interior from the exterior, they shall be sealed to prevent moisture and rodent entry and to deter air transfer. In addition, where conduits penetrate walls separating individually temperature or humidity controlled areas, they shall be sealed to prevent air circulation. Sealing methods and sealants shall be in accordance with the NEC.

4.6.2.1 Heavywall zinc coated rigid steel conduit.- Heavywall zinc coated rigid steel conduit shall conform to Federal Specification WW-C-581. Rigid steel conduit may be used in all locations. For installation below slab, on-grade, or underground, the conduit shall be factory coated with either 0.008 inch of epoxy resin per Spec MIL-R-21931, 0.020 inch of polyvinyl chloride or 0.063 inch of coal-tar enamel per Specification MIL-P-15147, or shall be field wrapped with 0.01-inch thick pipe wrapping plastic tape applied with 50% overlap. Fittings used underground shall be protected by field wrapping as specified herein for conduit. All fittings used with rigid steel conduit shall be the threaded type, of the same material as the conduit. Where conduits enter enclosures without threaded hubs, double locknuts (one on each side of the enclosure wall) shall be used to securely bond the conduit to the enclosure. In addition, a metallic insulated bushing shall be installed on the interior threaded end of the conduit to protect conductor insulation.

4.6.2.2 Electrical metallic tubing (EMT).- EMT shall conform to Federal Specification WW-C-563. EMT may be used only in dry interior locations, and where not subject to physical damage. EMT shall not be used on circuits above 600 volts or in sizes greater than 4 inches in diameter. Fittings used with EMT shall be standard compression-type fittings designed for this type of conduit, unless otherwise indicated. Screw-type fittings are not acceptable. Where conduits enter enclosures without threaded hubs, an appropriate connector with threads and locknut shall be used to securely bond the conduit to the enclosure. The connector body and locknut shall be installed so that firm contact is made on each side of the enclosure. In addition, the connectors shall be the insulated-throat type.

4.6.2.3 Intermediate metal conduit (IMC).- IMC shall be zinc coated steel, shall conform to UL Standard 1242, and shall bear the UL label. IMC shall not be used in hazardous locations. For installation below slab on grade or underground, protection per para. 4.6.2.1 shall be provided. Where it is necessary to fabricate IMC bends in the field, the tooling required to fabricate those bends shall be specifically designed for IMC. All fittings shall be of the threaded type, of the same material as the conduit. Where conduits enter enclosures without threaded hubs, double locknuts (one on each side of the enclosure wall) shall be used to securely bond the conduit to the enclosure. In addition, a metallic insulated bushing shall be installed on the interior threaded end of the conduit to protect conductor insulation.

4.6.2.4 Rigid aluminum conduit.- Rigid aluminum conduit shall conform to Federal Specification WW-C-540. Rigid aluminum conduit may be used only when required by the contract drawings or detailed specifications and in exposed,

dry locations. All fittings shall be of the threaded type, of the same material as the conduit. Where conduits enter enclosures without threaded hubs, double locknuts (one on each side of the enclosure wall) shall be used to securely bond the conduit to the enclosure. In addition, a metallic insulated bushing shall be installed on the interior threaded end of the conduit to protect conductor insulation. Rigid aluminum conduit shall not be used to enclose control, signal or data lines, other lines requiring electromagnetic shielding, or bare copper wire.

4.6.2.5 Rigid plastic conduit.- Rigid plastic conduit shall be heavywall PVC conforming to Federal Specification W-C-1094, Type II. Rigid plastic conduit used to protect electrical power conductors may only be used underground, or in concrete, or as a vertical riser to 6 inches above grade or floor surface for connection to metal conduit; and only when required by the contract drawings or specific job specifications. PVC fittings shall be used with PVC conduit and shall be assembled in accordance with manufacturer's instructions. A PVC threaded fitting with locknut and plastic bushing shall be used to connect PVC conduit to boxes or cabinets without threaded hubs. Rigid plastic conduit may be used to protect lightning protection system conductors and, in interior locations, to protect signal grounding conductors.

4.6.2.6 Flexible steel conduit.- Flexible steel conduit shall conform to Federal Specification WW-C-566. Flexible steel conduit shall be used for terminal connections to motors or motor driven equipment, and in lengths only up to 6 ft. for other applications permitted by the NEC. Liquid-tight flexible conduit shall be used outdoors and in wet locations. A separate ground conductor shall be provided across all flexible conduit in addition to the equipment grounding conductor run in the conduit with its related power conductors. This conductor shall be bonded to the connecting devices at each end of the flexible conduit.

4.6.2.7 Surface metal raceways.- Surface metal raceways shall conform to Federal Specification W-C-582. Surface metal raceways shall be installed only in exposed, dry locations not subject to physical damage. Surface metal raceways shall meet NEC requirements, however, they shall not be used for circuits above 600 volts.

4.6.2.8 Square duct.- Square duct shall conform to UL Standard 870. Square duct shall only be installed in exposed locations.

4.6.2.9 Cable rack systems

4.6.2.9.1 General.- Cable rack systems shall be of the ladder or ventilated trough type conforming to NEMA Standard VE 1, unless otherwise indicated. All components for each cable rack system shall be the product of a single manufacturer. Cable rack support spacing shall be as recommended by the manufacturer except that in no case shall spacing of supports exceed 6 feet.

4.6.2.9.2 Dimensions.- Straight sections, bends, tees, offsets, reducers, etc., for ladder-type cable rack systems shall consist of 3 inch minimum side channels with suitable cross channels (rungs) installed on 6 inch centers unless otherwise indicated. Straight sections, fittings, etc., for

ventilated-type cable rack systems, shall have 3 inch minimum high sides and a ventilated bottom with cross pieces 2 inches (maximum) wide on 3 inch (maximum) centers and openings 2 inches (maximum) wide. Cable rack widths shall be as shown on the drawings.

4.6.3 Raceway support systems

4.6.3.1 General.- Raceways shall be securely supported at intervals specified in the NEC and fastened in place with pipe straps, wall brackets, hangers, or ceiling trapezes. Fastenings shall be by wood screws, nails or screw-type nails to wood; by toggle bolts on hollow masonry units; by expansion-bolts on concrete or brick; by machine screws, welded threaded studs, or spring tension clamps on steel work. Nail type nylon anchors or threaded studs driven by a power charge and provided with lock washers and nuts may be used in lieu of expansion bolts, machine screws, or wood screws. Threaded C clamps with retainers may be used. Raceways or pipe straps shall not be welded to steel structures. Holes cut to a depth of more than 1-1/2 inch in reinforced concrete beams, or to a depth of more than 3/4 inch in reinforced concrete joists, shall not cut the main reinforcing bars. Holes not used shall be filled. In partitions of light steel construction, sheet-metal screws may be used. Raceways shall not be supported from sheet-metal roof decks. In suspended-ceiling construction, raceways shall not be fastened to the suspended-ceiling supports.

4.6.3.2 Telephone and signal raceways.- Telephone and signal system raceways shall be installed in accordance with the previous requirements for conduit and tubing, with the additional requirements that no length of run shall exceed 50 feet for 1/2-inch and 3/4-inch sizes, and 100 feet for 1-inch or larger sizes; and shall not contain more than two 90-degree bends or the equivalent. Pull or junction boxes shall be installed to comply with these limitations, whether or not indicated on the drawings. Bends in conduit, 1 inch and larger, shall have minimum inside radii of 10 times the nominal conduit diameter.

4.6.4 Conductors

4.6.4.1 Uninsulated conductors.- Uninsulated conductors shall be copper and in accordance with Federal Specification QQ-W-343.

4.6.4.2 Insulated conductors.- Unless otherwise indicated, insulated conductors shall be copper with thermoplastic or thermosetting insulation, type THW, THWN, and XHHW for general use, or type THHN for use in dry locations only, all insulated for 600 volts in accordance with Federal Specification J-C-30. Unless otherwise indicated, conductors No. 10 AWG and smaller shall be solid (unstranded), and conductors No. 8 AWG and larger shall be stranded. Minimum branch circuit conductor size shall be No. 12 AWG. Minimum control wire size shall be No. 14 AWG unless noted otherwise.

4.6.4.2.1 Fixture wiring.- Fixture wiring shall be thermoplastic insulated copper, rated for 600 volts, in accordance with Federal Specification J-C-30 and the NEC.

4.6.4.2.2 Color coding.- Feeder conductors to panels and to 3-phase circuits shall be color coded as specified herein. Single-phase branch circuits may be color coded in a like manner or identified with heat shrink labels embossed with the feeder panel name and circuit breaker number at each end. The color coding shall be continuous throughout the facility on each phase conductor to its point of utilization so that the conductor phase connection is readily identifiable. Equipment grounding conductors shall be color coded as described in para. 4.4.5. Conductors covered with green insulation with yellow, orange or red tracers shall be used for other grounding systems as described in para. 4.4.7. Neutral conductors shall be continuous white or gray unless more than one voltage system is run in the same raceway, box, or other type of enclosure. Neutral conductors of other systems shall be white or gray with identifiable colored tracers (not green). For conductors, No. 4 AWG and larger, where color coding is not available, color coded tape, half lapped for a minimum length of 3 inches shall be used. In no case, however, shall green insulated conductors be re-identified for purposes other than grounding, nor shall white or neutral grey conductors be re-identified as other than grounded (neutral) conductors. Where conductors are color coded in this manner, they shall be color coded in all junction boxes and pullboxes, accessible raceways, panelboards, outlets, and switches, as well as at all terminations. Conductors in accessible raceways shall be color coded so that by removing or opening any cover, the coding will be visible. Phase conductors shall be color coded as follows:

Single-Phase		Three-Phase	
120 Volts	120/208(240) Volts	120/208(240) Volts	277/480 Volts
Line - Black	Line 1 - Black	Phase A - Black	Phase A - Yellow
	Line 2 - Red	Phase B - Red	Phase B - Brown
Neutral - White	Neutral - White	Phase C - Blue	Phase C - Orange
		Neutral - White	Neutral - Grey/White

Color coding for conductors in control cables shall be in accordance with NEMA Standard WC-5. DC power conductors shall be color coded as follows: positive conductor, red with brown tracer; negative conductor, brown with red tracer.

4.6.4.3 Splices.- Splices shall be made only at outlets, junction boxes, or accessible raceways. Splices shall be made with solderless connectors conforming to Federal Specification W-S-610. Wire nuts may only be used to splice conductors sized No. 10 AWG and smaller. Compression connectors shall be used to splice conductors No. 8 AWG and larger. All splices, including those made with insulated wire nuts, shall be insulated with electrical tape or heat-shrink tubing to a level equal to that of the factory insulated conductors. Connections between aluminum and copper conductors shall be made only with materials approved for this purpose in accordance with the applicable portions of the NEC, and with devices approved for this purpose by UL.

4.7 Boxes.- Boxes shall be either the cast-metal threaded-hub type conforming to Federal Specification W-C-586, galvanized steel type conforming to Federal Specification W-J-800, or metal outlet boxes conforming to NEMA OS 1. Cast

aluminum boxes shall be used only with aluminum conduit. Where not sized on the drawings, boxes shall be sized in accordance with the NEC.

4.7.1 Applications.- Boxes shall be provided in the wiring or raceway system for pulling wires, making connections, and mounting devices or fixtures. On exterior surfaces and in wet locations, boxes for metal raceways shall be of the cast-metal threaded-hub type. In hazardous areas, boxes shall be explosion proof. Boxes in other locations shall be cast-metal threaded-hub type or one-piece galvanized steel with covers designed for surface installation. Non-metallic boxes may be used only with non-metallic raceway systems. Each box shall have the volume required by the NEC for the number and size of conductors in the box. Each outlet box shall have a machine screw which fits into a tapped hole in the box for the ground connection. Boxes for mounting lighting fixtures shall be not less than 4 inches square. Boxes installed for concealed wiring shall be provided with extension rings or plaster covers. The front edge of the box shall be flush or recessed not more than 1/4-inch from the finished wall surface (whether the finished surface is drywall, or drywall and a sound-absorbing material. Boxes for use in masonry-block or tile walls shall be square-cornered tile-type, or standard boxes having square-cornered tile-type covers. Cast-metal boxes installed in wet locations and boxes installed flush with exterior surfaces shall be gasketed. Separate boxes shall be provided for flush or recessed fixtures where required by the fixture terminal operating temperature, and fixtures shall be readily removable for access to the boxes unless ceiling access panels are provided. Boxes for fixtures on suspended ceilings shall be supported independently of the ceiling supports. Boxes shall not be supported from sheet-metal roof decks.

4.7.2 Supports.- Boxes and supports shall be fastened to wood with wood screws, nails, or screw-type nails of equal holding strength, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel work. Threaded studs driven by powder charge and provided with lockwashers and nuts, or nail-type nylon anchors may be used in lieu of expansion shields, or machine screws. In open overhead spaces, cast-metal boxes threaded to raceways need not be separately supported except where used for fixture support; cast-metal boxes having threadless connectors and sheet-metal boxes shall be supported directly from the building structure or by bar hangers. Where bar hangers are used, the bar shall be attached to raceways on opposite sides of the box and the raceway shall be supported with an approved fastener not more than 24 inches from the box. Penetration shall be no more than 1-1/2 inches into reinforced concrete beams nor more than 3/4-inch into reinforced concrete joists. Main reinforcing steel shall not be cut.

4.8 Wiring devices

4.8.1 Receptacles.- Receptacles shall be of the voltage and current rating indicated on the drawings. All receptacles shall be specification grade in accordance with NEMA STD WD-1. Wiring terminals shall be of the screw-type. Receptacles with push-in connections or a combination of screw-type and push-in connectors are not acceptable. Unless noted otherwise, receptacles shall be installed 12 inches above finished floor. All receptacles, unless they are of the isolated-ground type, shall be grounded by the installation of

a green grounding pigtail from the receptacle grounding screw directly to the grounding lug on the outlet box where the green equipment grounding conductor is terminated. The equipment grounding conductor shall be installed with the receptacle power conductors and shall terminate at the ground bus in the electrical service panel.

4.8.1.1 Duplex receptacles.- Unless otherwise indicated, general purpose duplex receptacles shall be specification grade, 15 ampere minimum rating, 125 volt, grounding type (NEMA 5-15R per NEMA standard WD-1).

4.8.1.2 250 volt receptacles.- Unless otherwise indicated, 250-volt receptacles shall be specification grade, grounded type with a minimum rating of 20 amperes (NEMA 6-20R per NEMA Standard WD-1).

4.8.1.3 Ground fault interrupting (GFI) receptacles.- GFI receptacles shall be installed in all locations required by the NEC and in other locations as indicated on the drawings. GFI receptacles shall be 125-volt, duplex, UL Group I, Class A, rated for 15 amperes minimum. All exterior GFI receptacles shall be mounted in weatherproof cast outlet boxes with weatherproof covers.

4.8.1.4 Clock outlets.- Clock outlets shall consist of an outlet box and a single receptacle with a clock outlet plate. The receptacle shall be recessed sufficiently within the box to allow the complete insertion of a standard cap, flush with the plate. A clip or support for hanging the clock shall be secured to the top of the plate.

4.8.1.5 Isolated ground pin receptacles.- When isolated ground pin receptacles are shown in the contract documents, they shall be installed in accordance with the NEC. Isolated ground pin receptacles shall only be used where shown on the drawings.

4.8.1.6 Plug-in strip outlets

4.8.1.6.1 General.- Fixed multi-outlet assemblies shall consist of a surface metal raceway with receptacles as indicated on the drawings. Phase and neutral conductors shall not be smaller than No. 12 AWG and shall have the type of insulation specified for branch circuit conductors. In addition, a No. 12 AWG or larger green insulated equipment grounding conductor having the same insulation as the phase conductors and meeting requirements of the NEC shall be installed. This grounding conductor shall connect all receptacle ground terminals and each section of the surface metal raceway, and shall be securely connected to the equipment grounding conductor from the branch power panel. Where more than one circuit is indicated as serving a group of similar receptacles in a common raceway, adjacent receptacles shall not be connected to the same circuit.

4.8.1.6.2 Associated hardware.- Surface metal raceways shall be provided with snap-on blank covers and/or snap-on receptacle covers for the receptacles furnished, all manufactured by the raceway manufacturer. They shall be installed to prevent open cracks. Where industry standard device plates are to be installed on raceways, snap-on blank covers shall be accurately cut to avoid

open cracks. Fittings, elbows, clips, mounting straps, connection blocks, and insulators, shall be provided as required for a complete installation.

4.8.1.7 Emergency Light Receptacles.- Emergency light receptacles shall be 15 ampere, 125 volt, grounding type single receptacles (NEMA 5-15R, Std. WD-1).

4.8.2 Wall switches.- Single-pole and three-way wall switches shall be specification grade, rated 120/277 volts, and shall be fully rated 20 amperes, AC only. Wiring terminals shall be of the screw type. Switches with push-in connections or a combination of screw-type and push-in connectors are not acceptable. Where switches have grounding terminals, they shall be grounded with a green grounding pigtail connected from the switch grounding screw directly to the grounding lug on the outlet box where the green equipment grounding conductor is terminated. Switches shall be the quiet-operating type. Not more than one switch shall be installed in a single gang position.

4.8.3 Device plates.- Plates of the one-piece type shall be provided for all outlets and fittings to suit the devices installed. Plate screws shall be of metal with countersunk heads, in a color to match the finish of the plate. Device plate color shall be approved by the Contracting Officer. Plates shall be installed with all four edges in continuous contact with finished wall surfaces without the use of mats or similar devices. Plaster fillings will not be permitted. Plates shall be installed with an alignment tolerance of 1/16 inch. The use of sectional type device plates will not be permitted. Plates installed in wet locations shall be gasketed. Device plates for telephone and intercommunication outlets shall have a 3/8-inch bushed opening in the center or a dome-shaped grommet on the side. Where required, device plates for telephones may be more than one piece type.

4.8.4 Photoelectric control.- Unless otherwise indicated, photoelectric controls for floodlighting or obstruction lighting shall be 120 volt, 3000 watt, single-pole, single-throw, double-break type. Photoelectric controls shall be mounted in appropriate weatherproof housings. They shall be installed on the building exterior, faced in a northerly direction.

4.8.5 Time switches.- Unless otherwise indicated, automatic electric motor driven time switches shall be single-pole, single-throw, 120 volt, 40 ampere capacity. Time switches shall have a 24-hour dial with two on-off operations in a 24-hour period. Timer motors shall be self-starting, heavy duty with lifetime lubrication. Time switches shall have spring driven reserve power supplies, which shall automatically rewind on power restoration, or shall have battery-backed power supplies with batteries that automatically recharge on power restoration.

4.9 Service equipment

4.9.1 Power.- Service entrance equipment and installation for power shall be in accordance with the regulations of the local utility providing service and the NEC.

4.9.1.1 Service entrance conduits.- Service entrance conduits shall be installed as shown on the drawings and shall be heavywall zinc coated rigid steel unless otherwise indicated. Grounding bushings shall be installed on both ends of the service entrance conduit. Refer to specification FAA-C-1391 for installation of underground cables.

4.9.1.1.1 Underground service.- Underground service entrance conduits shall be installed a minimum of 2 feet below finished grade. Service entrance conduit shall be electrically continuous between the service disconnecting means and the facility transformer housing.

4.9.1.1.2 Aerial service.- Aerial service entrances shall be installed from the service equipment to a point on the exterior of the building. A minimum of 4 feet of slack in all conductors shall be extended from an appropriate weatherproof entrance fitting to permit connection to the service drop. Conduit shall be concealed within the building where possible and conduit penetrations into the building shall be caulked with sealing compound.

4.9.1.2 Service disconnecting means.- Service equipment shall be a fused disconnect switch, separately mounted circuit breaker, or main circuit breaker in the main distribution panel. All switches and circuit breakers used as service entrance disconnecting means shall be UL rated for service equipment.

4.9.1.3 AC power surge protection.- An AC power surge arrester shall be installed adjacent to (within 12 inches), and connected to the line side of the main service disconnecting means. This arrester shall be compatible with the service voltage, and shall be wired to avoid loops, sharp bends and kinks, and to minimize the number of bends. Arrester conductors shall be No. 4 AWG insulated copper or larger unless a smaller size is recommended by the arrester manufacturer.

4.9.2 Signal and communications

4.9.2.1 Entrance conduits.- Conduit materials shall be heavywall zinc coated rigid steel unless otherwise indicated. Except where otherwise indicated, underground conduits shall be a minimum of 2 feet below finished grade and extend at least 5 feet beyond the grounding electrode system. The exterior ends of conduits shall be bonded to the grounding electrode system with No. 2 AWG bare copper conductor by exothermic welds or FAA-approved pressure connectors. Conduits installed for use by others, such as for telephone, communications, electronic signals, etc., shall have both ends capped.

4.9.2.2 Transient protection demarcation box for electronic landlines.- When indicated on the drawings, a metal NEMA 1 junction box shall be installed where electronic landlines or conduits enter the facility. This box will house terminal boards, cables, and circuit transient protectors as shown on the contract drawings. The box shall be sized as shown on the drawings and be either galvanized or factory painted.

4.10 Panelboards

4.10.1 General.- Panelboards shall be circuit-breaker-equipped, dead-front type, shall conform to Federal Specification W-P-115, Type I, Class 1, and shall be listed by UL except for installations which require special panelboards to incorporate items not available as UL listed. Panelboards shall be mounted so that the height to the top of the panelboard shall not exceed 81 inches above the finished floor level. Unless otherwise specified, panelboards shall have a full piano hinged front cover with a piano hinged door in that cover for access to circuit breaker switches. All door hinges shall be concealed. Doors shall have flush type cylinder locks and catches. Doors over 48 inches in height shall have auxiliary fasteners on top and bottom. All locks in a project shall be keyed alike, and two keys shall be furnished with each lock. Directories shall be type written to indicate the load served by each circuit and shall be mounted on the inside of the door in a holder with a protective covering. The directory shall be arranged so that the typed entries simulate circuit breaker positions in the panelboard.

4.10.2 Wiring gutters.- The minimum size of side wiring gutters shall be 4 inches for power feeders up to and including 100 amperes, 6 inches for power feeders over 100 amperes and up to 225 amperes, and 8 inches for power feeders over 225 amperes and up to 600 amperes.

4.10.3 Circuit breakers.- Except as noted in para. 4.10.3.1, all circuit breakers shall be UL listed, quick-make, quick-break, bolt-on, thermal magnetic type, conforming to Federal Specification W-C-375. Circuit breaker interrupting ratings, established from facility short circuit calculations, shall be as shown on the drawings. Circuit breakers shall also have trip ratings, voltage ratings, and number of poles as defined on the drawings. All circuit breakers shall have a trip indicating feature. Single-pole breakers shall be full-size modules. Two-pole and three-pole breakers shall be physically sized in even multiples of a single-pole breaker. Breakers shall be sized so that two single-pole breakers can not fit in a single housing. Multipole circuit breakers shall have an internal common trip mechanism. Devices with an adjustable magnetic trip shall be factory set to the "low" value. All circuit breakers and the panelboards in which the breakers are installed shall be products of the same manufacturer.

4.10.3.1 Plug-in Circuit Breakers.- In small panels rated at 60 amperes or less, and not supplying power to FAA mission equipment, plug-in circuit breakers may be substituted for bolt-on breakers.

4.10.4 Bus bars.- Unless otherwise indicated, buses shall be copper. Bus capacity shall be as indicated on the drawings. Where bus capacity is not indicated on the drawings, the capacity shall be equal to or greater than the panelboard feeder overcurrent protective device. Except as indicated in para. 4.10.3.1, circuit breaker current-carrying connections shall be bolted. Stab-in types are not acceptable. Bus bar connections to branch circuit breakers shall be of the sequence phase type. The branch circuits shall be connected to the individual circuit breakers as indicated on the drawings. The neutral bus shall be insulated from all panelboards except where the panelboard is used as the service disconnecting means. All panelboards shall

have an uninsulated ground bus that is separate from the neutral bus. The ground bus shall be securely bonded to the cabinet and adequately sized for the panelboard capacity. The ground bus shall only be bonded to the neutral bus at the service disconnecting means. Where "provisions for," "future," or "space" is noted on the drawings, the panelboard shall be equipped with bus connections for the future installation of circuit breakers.

4.11 Self enclosed circuit breakers

4.11.1 General.- Self enclosed circuit breaker interrupting ratings, established from facility short circuit calculations, shall be as shown on the drawings. Self enclosed circuit breakers shall be supplied with trip rating, voltage rating and number of poles as indicated on the drawings. Circuit breakers shall comply with Federal Specification W-C-375.

4.11.2 Requirements.- Circuit breakers shall be of the molded-case type, shall have a quick-make and quick-break toggle mechanism, inverse-time trip characteristics and shall be trip-free on overload or short-circuit. Automatic release shall be secured by a bi-metallic thermal element releasing the mechanism latch. In addition, a magnetic armature shall be provided to trip the breaker instantaneously for short-circuit currents above the overload range. Automatic tripping shall be indicated by a handle position between the manual OFF and ON positions.

4.12 Safety switches.- Safety switches shall conform to Federal Specification W-S-865, and shall be type "HD," heavy duty, locking type unless otherwise indicated. Switches mounted in dry locations shall be in NEMA type 1 enclosures. Switches installed outdoors, or in damp locations shall be mounted in NEMA type 3R enclosures. Switches shall be of the voltage and current ratings indicated on the drawings, and each shall be capable of interrupting the locked-rotor current of the motor for which it is to be used. The locked-rotor current will be assumed to be ten (10) times the full rated load current. Switches shall be the quick-make, quick-break type. Except for ground lugs which shall be bonded to the housing, all parts shall be mounted on insulating bases to permit replacement of any part from the front of the switch. All current-carrying parts shall be of high-conductivity copper unless otherwise specified, and shall be designed to carry rated current without excessive heating. Switch contacts shall be silver-tungsten or plated to minimize corrosion, pitting and oxidation and to assure suitable conductivity.

4.13 Cabinets.- Telephone and signal systems cabinets shall be constructed of code gauge zinc coated sheet steel, and shall meet the requirements of UL Standard 50. Cabinets shall be constructed with interior dimensions not less than those indicated on the drawings. Cabinets shall be mounted so that the height to the top of the cabinet does not exceed 81 inches above the finished floor level. A locking catch and two keys shall be provided with each cabinet unless otherwise indicated. Cabinets shall also be provided with a 5/8-inch plywood backboard unless otherwise indicated.

4.14 Motors and controls

4.14.1 Motors.- Motors furnished under this specification shall be of sufficient size for the duty to be performed, and shall not exceed the full-load rating when the driven equipment is operating at specified capacity. Motors shall be rated for the voltage of the system to which they are to be connected. Unless otherwise indicated, all motors shall have open frames, and continuous-duty classifications. Polyphase motors shall conform to Federal Specification CC-M-1807, and shall be type II, class 3, minimum insulation class B, squirrel-cage type, having normal starting-torque and low-starting-current characteristics, unless otherwise specified. When motor horsepower ratings are indicated on electrical drawings, these ratings are only approximate. Higher ratings may be required to adequately power driven equipment selected by the contractor for the duty to be performed.

4.14.2 Motor controls.- Each motor, 1/8 horsepower or larger, shall have overload protection in each phase, or other equally rated method in accordance with the NEC. The overload-protection device shall be provided either integral with the motor (except that motors to be installed in locations that are not readily accessible shall have the overload protection device located for easy access to the reset button), or with the control, or shall be mounted in a separate enclosure. Unless otherwise indicated, the protective device shall be of the manual reset type. Single or double-pole tumbler switches specifically designed for AC operation may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating. Automatic control devices such as thermostats and float or pressure switches may control the starting and stopping of motors directly, provided the devices used are designed for that purpose and have an adequate horsepower rating. When the automatic control device operates the motor directly, a double-throw, three-position tumbler or rotary switch shall be provided for manual control. When the automatic control device actuates the pilot control circuit of a magnetic starter, a three-position selector switch marked Manual-Off-Automatic shall be provided. Connections to the selector switch shall be such that only the normal automatic regulatory control devices will be bypassed when the switch is in the Manual position and all safety control devices, such as low or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch.

4.14.2.1 Reduced-voltage controllers.- Reduced-voltage controllers shall be provided for polyphase motors when indicated on the drawings. Unless otherwise indicated, reduced-voltage starters shall be of the single-step autotransformer, reactor, or resistor type having an adjustable time interval between application of reduced and full voltages to the motors. Wye-delta reduced-voltage starters or partial winding increment starters having an adjustable time delay between application of voltage to the first and second winding of a motor may be used in lieu of the reduced-voltage starters specified above for starting of motor-generator sets, centrifugally operated equipment, or reciprocating compressors provided with automatic unloaders.

4.14.3 Motor disconnecting means.- Each motor shall be provided with a disconnecting means and a manually operated switch as shown on the drawings or

when required by the NEC. For single-phase motors, a single-pole or double-pole toggle switch, rated only for AC, will be acceptable for capacities less than 30 amperes, provided the ampere rating of the switch is at least 125 percent of the motor rating. Enclosed safety switches shall conform with para. 4.12. Switches shall disconnect all ungrounded conductors.

4.15 Dry-type transformers

4.15.1 General.- Dry-type transformers shall be of the sizes and characteristics shown on drawings. Unless otherwise indicated, the design, manufacture, and testing of dry-type transformers, and the methods of conducting tests and preparing reports shall be in accordance with NEMA ST 20, and UL standards. These transformers shall be dry-type self-cooled (Class AA) as defined by ANSI/IEEE C57.12.80. Unless otherwise indicated, minimum Basic Impulse Insulation Levels (BIL) shall be in accordance with IEEE STD 141.

4.15.2 Windings and taps.- Dry-type transformers shall be provided with separate primary and separate secondary windings for each phase. Unless otherwise indicated, each primary winding of each transformer rated 15 KVA and greater shall be provided with four taps, two of which shall provide 2-1/2 percent increments above full rated voltage and two of which shall provide 2-1/2 percent increments below full rated voltage. Each primary winding of each transformer rated below 15 KVA shall be provided with not less than two taps, each providing a 5 percent increment above and below full rated voltage.

4.15.3 Insulation.- Transformers having ratings not exceeding 25 KVA shall have 185°C insulation and shall be rated for continuous operation at rated KVA. Transformers having ratings exceeding 25 KVA shall have 220°C insulation and shall be rated for continuous operation at rated KVA.

4.15.4 Terminal compartments.- Each dry-type transformer shall be provided with a suitable terminal compartment to accommodate the required primary and secondary wiring connections, and side or bottom conduit entrance. Transformers having ratings not exceeding 25 KVA shall be provided with terminal leads equipped with factory installed and supported connectors. Transformers rated greater than 25 KVA shall have terminal boards equipped with factory installed clamp-type connectors. The terminal compartment temperature shall not exceed 75°C when the transformer is operating continuously at rated load with an ambient temperature of 40°C.

4.15.5 Sound levels and vibration isolation.- Sound levels of dry-type transformers shall be determined in accordance with NEMA Standard ST 20. Levels shall not exceed 40 db for transformers rated at 9 KVA or less; 45 db for transformers rated over 9 KVA but not over 50 KVA; and 50 db for transformers rated over 50 KVA but not over 150 KVA. All dry-type transformers 45 KVA and greater shall have integral vibration isolation supports between the core and coil assembly and the transformer enclosure. Transformers of lesser rating shall have either integral or external vibration isolation supports. Conduit connections to transformers shall be made with flexible metal conduit, nominally 12 inches in length but not more than 36 inches in length.

4.15.6 Enclosures.- Single-phase transformers larger than 25 KVA and three-phase transformers larger than 15 KVA shall be fully encased in steel enclosures. Transformers smaller than 15 KVA shall be fully encased in steel enclosures with or without compound fill, or shall have exposed cores, impregnated windings, and steel enclosures encircling all live parts. Enclosures shall be bonded to the grounding system. The surface temperature of the transformer shall not exceed 65°C when the transformer is operating continuously at rated load with an ambient temperature of 40°C.

4.15.7 Mounting.- Unless otherwise indicated on drawings, dry-type transformers having ratings not exceeding 25 KVA shall be suitable for wall mounting. Shop drawings of wall brackets and platforms for transformers shall be submitted for approval.

4.16 Identification.- Motor controllers, panelboards, switches and self-enclosed circuit breakers shall be identified with a name plate showing the functional name of the unit, voltage utilized, the number of phases, and other pertinent information. Switches for local lighting need not be identified. Additional equipment shall be identified if called for on the drawings.

4.16.1 Name plates.- Name plates shall be non-ferrous metal or rigid plastic, stamped, embossed or engraved with 3/8-inch minimum height characters. The plates shall be secured to the equipment with a weather-proof bonding material or a minimum of two screws.

4.17 Fuses.- A complete set of fuses shall be installed and one set of spares shall be furnished for each fusible device. Time and current tripping characteristics of fuses serving motors or connected in series with circuit breakers shall be coordinated for proper operation. Fuses shall have a voltage rating not less than the circuit voltage. Fuse interrupting ratings, established from facility short circuit calculations, shall be as shown on the drawings, except that these interrupting ratings shall be not less than 100,000 amperes in branch and distribution circuits, and not less than 200,000 amperes in a service entrance switch.

4.18 Lamps and lighting fixtures

4.18.1 General.- Lamps and lighting fixtures shall be of the types indicated on the drawings. All lighting fixtures shall be UL approved and shall bear the UL label. All incandescent lamps shall be rated for 130 volts unless otherwise indicated.

4.18.2 Fluorescent fixtures.- Unless otherwise indicated, fluorescent fixture lenses shall be the prismatic-type, made of virgin acrylic. Fluorescent lamps shall be rapid start, cool white unless otherwise indicated. Ballasts for fluorescent fixtures shall be class P, rapid start, high power factor type, without automatic thermal resetting capability, conforming to Federal Specification W-B-30. Unless otherwise indicated, all ballasts shall be provided with factory installed choke-type radio frequency interference suppressors. All ballasts shall bear the CBM/ETL label. Lampholders shall have silver plated contacts, and shall conform to standard UL 542.

4.18.2.1 Recessed fluorescent fixtures.- Recessed fluorescent fixtures shall conform to Federal Specification W-F-1662 and shall be installed in suspended ceiling openings. These fixtures shall have adjustable fittings to permit alignment with ceiling panels.

4.18.2.2 Suspended fluorescent fixtures.- Pendant-mount fluorescent fixtures shall conform to Federal Specification W-F-414 and shall be of the types indicated on the drawings. Single-unit suspended fluorescent fixtures shall have twin-stem hangers. Multiple-unit or continuous row fluorescent units shall have tubing or a stem for wiring at one point, and tubing or a stem suspension provided for each unit length of chassis, including one at each end.

4.18.2.3 Suspended incandescent fixtures.- Pendant-mounted incandescent fixtures shall be provided with swivel hangers to insure a plumb installation.

4.18.3 Emergency lights.- Emergency lights shall conform to Federal Specification W-L-305, type I, class I, style D or E, with the number of heads as indicated on the drawings. Emergency light sets shall be connected to the wiring system by a cord no more than 3 feet in length and a single receptacle.

4.18.4 High intensity discharge (HID) lamps.- HID lamps including mercury vapor, metal halide, and high or low pressure sodium shall be as indicated on the drawings. High power factor, constant wattage ballasts shall be furnished with HID lamps. Mercury vapor lamps shall be the color improved type.

4.19 Painting and finishing. Where factory finishes are not adequate to protect metal surfaces from corrosion, the contractor shall paint exposed surfaces prior to or after installation. All marred or damaged surfaces, except exposed metal for grounding purposes, shall be refinished to leave a smooth, uniform finish at final inspection.

4.20 Repair of existing work.- Electrical work shall be carefully planned. Where cutting, channeling, chasing, or drilling of floors, wall partitions, ceilings, or other surfaces is necessary for the proper installation, support, or anchorage of the conduit, raceways, or other electrical work, it shall be carefully done. The contractor shall repair, with equal material by skilled workers, any damage to facilities caused by the contractor's workers or equipment. Prior Contracting Officer approval must be obtained for the materials, workers, time of day or night, repair method, and for temporary or permanent repairs purposes. On completion, repair work shall be inspected and approved by the Contracting Officer with the concurrence of any other affected parties such as utility companies and airport authorities.

5. QUALITY ASSURANCE PROVISIONS

5.1 List of materials and equipment.- Within 15 days after receiving notice to proceed, and before installing any materials or equipment, the contractor shall submit six copies of the complete list of materials and equipment to the Contracting Officer for approval.

5.1.1 Information required.- This list shall include manufacturer's style or catalog numbers. Partial lists submitted from time to time shall not be

considered as fulfilling this requirement. Approval of materials will be based on manufacturer's published data. Approval of materials and equipment will be tentative, subject to submission of complete shop drawings, when required, indicating compliance with the contract documents.

5.1.2 Statement.- A manufacturer's statement indicating complete compliance with the applicable federal specification, military specification, or standard of the American Society for Testing and Materials, National Electrical Manufacturers Association, or other commercial standard, is acceptable as indicating compliance with contract documents.

5.2 Shop drawings.- By direction of the Contracting Officer, the contractor shall submit shop drawings for materials and equipment not completely identified by information submitted in the materials and equipment lists. This information shall include, but is not limited to panelboards, lighting fixtures, cable trays, switchgear, transformers, busways, cabinets, and lightning protection systems. Six copies of all shop drawings shall be submitted for approval at least 30 days prior to proposed installation.

5.2.1 Coordination.- Drawings and submitted data shall be checked and coordinated with the work of other construction trades involved, before they are submitted for approval, and shall bear the contractor's stamp of approval as evidence of such checking and coordination.

5.2.2 Required data.- Drawings and submitted data shall be complete, assembled in sets and shall bear the date, drawing revision number, name of project or facility, name of contractor and subcontractor, and the clear identity of contents and location of work. The contractor shall submit all drawings and data sufficiently in advance of contract requirements to allow ample time for checking, resubmitting, and rechecking. The contractor shall allow 30 calendar days for review of any one submission.

5.2.3 Approval.- The approval of drawings and submitted data will be general, but except as otherwise provided herein or in the contract, approval shall not be construed as (1) permitting any departure from the contract requirements; (2) relieving the contractor of the responsibility for any errors, including details, dimensions, materials, etc.; or (3) approving departures from full size details furnished by the Contracting Officer.

5.2.4 Variations.- If drawings show variations from the contract requirements because of standard shop practice or for other reasons, the contractor shall describe such variations in a letter of transmittal to the Contracting Officer. If acceptable, the Contracting Officer may approve any or all such variations, subject to a proper adjustment in the contract. Contractors failing to describe such variations shall not be relieved of the responsibility for executing the work in accordance with the contract, even though such drawings have been approved.

5.2.5 Submission.- The contractor shall submit and obtain approval of shop drawings by the Contracting Officer before ordering materials or proceeding with any work associated with the shop drawings.

5.3 Tests

5.3.1 General.- Unless otherwise indicated, the contractor shall furnish all test instruments, materials and labor necessary to perform the following tests. All tests shall be performed in the presence of the Contracting Officer or his designated representative. All instruments shall have been calibrated within a period of two years preceding testing. Calibrations shall be traceable to applicable industry recognized standards.

5.3.2 Cables.- All cables shall be tested prior to installation and again upon completion of the installation. All testing shall be accomplished before connection is made to any existing equipment.

5.3.3 Load balancing.- After the electrical installation has been completed, the contractor shall take current readings with a clamp-on ammeter on each phase of each panelboard feeder, and on the main service conductors. The contractor shall redistribute single-phase loads where there is greater than a 20% difference between readings in any two phases. Where load balancing requires moving a conductor between phases, the original conductor shall be re-identified by tape or tags in accordance with para. 4.6.4.2.2, Color coding. The contractor shall notify the Contracting Officer of any phase loaded above 80% of the rating of its overcurrent protective device.

5.3.4 Insulation resistance tests.- Feeder and branch circuit insulation tests shall be performed after installation, but before connection to fixtures or appliances. Motors shall be tested for grounds or short circuits after installation but before start-up. All conductors shall test free from short circuits and grounds, and have a minimum phase-to-phase and phase-to-ground insulation resistance of 30 megohms when measured with a 500-volt DC insulation resistance tester. The contractor shall submit a letter type test report to the Contracting Officer prior to final FAA inspection of the contractor's work. The report shall list the tests performed and results obtained.

5.3.5 Neutral isolation tests.- For all new installations, the neutral in the service entrance switch shall be tested for isolation from ground with an ohmmeter capable of reading greater than 20,000 ohms. The procedure to be used is detailed in Appendix A. This procedures can also be used to determine if there are any other neutral-ground connections on the load side of the service disconnecting means.

5.3.6 Earth resistance test.- To demonstrate compliance with para. 4.4.4, the contractor shall measure the resistance of the grounding electrode system. Tests shall not be conducted within 48 hours of a rainfall or in frozen soil. The contractor shall immediately notify the Contracting Officer if the specified resistance is not obtained. Upon project completion, the contractor shall also submit a written test report to the Contracting Officer, defining the test procedure and results obtained.

5.3.7 Operating Test.- After the interior wiring system installation is completed, and at such time as the Contracting Officer may direct, the contractor shall conduct an operating test for approval. The equipment shall be demonstrated to operate in accordance with the requirements of this

specification. The test shall be performed in the presence of the Contracting Officer or designated representative.

6. NOTES

6.1 General.- This specification is to be used as part of the contract documentation for construction and facility modification projects that do not require major design efforts. No waivers to contractors, other than those indicated as alternatives, are allowed. This specification is not to be used as a design guide. For design information, consult FAA-STD-019, "Lightning Protection, Grounding, Bonding and Shielding Requirements for Facilities"; FAA-STD-020, "Transient Protection, Grounding, Bonding and Shielding Requirements for Equipment"; FAA Order 6950.19, "Practices and Procedures for Lightning Protection, Grounding, Bonding, and Shielding Implementation"; FAA Order 6950.20, Considerations for Lightning Protection, Grounding, Bonding and Shielding" and other documentation as applicable.

6.2 Conflicts between documents.- In all but the smallest of modification or construction contracts, conflicts are unavoidable between the various documents cited in the contract or referenced in an included specification. Any proposal request using this document should contain the following provisions: "Prospective contractors shall, as part of their proposals, enumerate, identify, and list conflicts that exist within the contract documents, and between those documents and the rules, regulations, and codes of the local utility company and local, county or state governing bodies."

Appendix A

TEST TO DETERMINE IF NEUTRAL CONDUCTORS ARE GROUNDED PROPERLY (NO GROUND CONNECTIONS ON THE LOAD SIDE AFTER THE SERVICE ENTRANCE DISCONNECTING MEANS)

EQUIPMENT NEEDED: Volt-ohm meter. Flash light, allen wrenches, screw drivers, socket wrenches, wire markers.

NOTE 1: Resistance test: readings less than 20,000 ohms indicate "bad", readings equal to or greater than 20,000 ohms indicate "good".

NOTE 2: Capacitors on the neutral line will effect readings. Initial readings may indicate a short circuit, but will often increase to an acceptable level as these capacitors are charged. Use the steady state reading.

NOTE 3: Step 21 can be difficult. Because load side neutral conductors are usually not identified, it may be difficult to locate the end of the conductor that is not at the disconnect.

STEPS:

1. Request a shutdown of all facilities using power at the site.
2. Review and verify the one-line power diagram for the site.
3. Identify the service disconnecting means.
4. Lock out all standby power sources.
5. Remove power by opening the service disconnecting means.

CAUTION: Voltage is present at the line side.

6. Verify that no voltage is present at the load side with the voltmeter using progressively lower scales .
7. Disconnect the line side neutral from the neutral bar.
8. Disconnect the grounding electrode conductor from the neutral bar.
9. Disconnect the main bonding jumper from the neutral bar (this may be a screw).
10. Disconnect all grounding conductors from the neutral bar.
11. If a lightning arrester is present, remove its neutral and ground conductors from the neutral bar.
12. Only load side neutral conductors are now connected to the neutral bar.
13. Measure the resistance between the neutral bar and case. See Note 1.
14. If the test is "good", reconnect all conductors and restores the system: END OF TEST.
15. If the test is "bad" remove a load side neutral conductor from the neutral bar.
16. Measure the resistance between the removed load side neutral conductor and the case. Refer to note 1.
17. If the test is "good", reconnect this conductor to the neutral bar.
18. If the test is "bad", tag the conductor and leave it disconnected.
19. Repeat Step 13 until the test is "good". See Note 1.
20. Determine the circuit of each "tagged" conductor.
21. This tagged conductor is grounded somewhere within the load. Locate and remove the ground connection at the load.
22. Reconnect all conductors to the neutral bar after they have been cleared.
23. Return Step 13.